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(54) **Stencil sheet and method for perforating the same**

(57) Provided is a stencil sheet excellent in uniformity in solid print portion, improved in uneven density and setoff, and further excellent in resolution of small letters. A method for perforation of the stencil sheet is also provided. The stencil sheet comprises a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers, which has an average airflow resistance in a range of 0.05-0.15 Kpa · s/m as measured at a perforated part of 20-50 % in opening ratio. The stencil sheet preferably has a wet tensile strength of 200 gf/cm or more. The thermoplastic resin film is preferably a polyester resin film, and the thermoplastic fibers are preferably made of a polyester resin. When perforation is made in a stencil sheet to form many fine openings corresponding to an image to be printed, good image is obtained by carrying out the perforation to give an average airflow resistance of 0.05-0.15 Kpa · s/m at the perforated part of the stencil sheet.

## Description

[0001] The present invention relates to a stencil sheet, and more particularly relates to a stencil sheet which is suitable for thermal perforation by flash irradiation with halogen lamp, xenon lamp, flash bulb or the like, infrared irradiation, pulse irradiation with laser beams, or by thermal head, and excellent in printing characteristics, especially in uniformity of solid portions of printed images with causing no uneven density or offset. It also relates to a method for perforating a stencil sheet.

[0002] Hitherto, as stencil sheets used for stencil printing, there are known those which comprise a thermoplastic resin film such as polyester film, polyvinylidene chloride film or polypropylene film and a porous substrate comprising a thin paper, nonwoven fabric, or gauze made of natural fibers, synthetic fibers or a mixture thereof, the film and the substrate being laminated to each other with an adhesive.

[0003] However, printed images obtained using these conventional stencil sheets are not necessarily satisfactory in sharpness, especially, in uniformity of solid portions. Various reasons are considered for the lack of sharpness of the printed images. When a thin paper comprising natural fibers is used as a porous substrate, permeation of ink is apt to become uneven because of relatively thick and uneven fiber diameter. Moreover, smoothness of the surface of the laminated film is deteriorated due to the thick fibers to cause insufficient contact with a thermal head in perforation of the stencil sheet, resulting in deficient perforations. As a result, the resulting images become faded, or voids are generated in the solid portions. Furthermore, since foreign matters coming from natural fibers cannot sufficiently be removed at the production step of the substrates, they hinder passing of ink, causing voids in the printed images. Even when a thin paper made from a mixture of natural fibers and synthetic fibers is used as a porous substrate, improvement is still not sufficient. See, for example, JP-A-59-2896, JP-A-59-16793, and JP-A-2-67197.

[0004] Furthermore, a stencil sheet comprising a film laminated to a nonwoven fabric made of synthetic fibers has been proposed. See, for example, JP-A-2-67197 and JP-A-5-309967. However, uneven density so-called "fibrous texture" is produced and besides sufficient strength of the sheet cannot be assured. Thus, this has not yet been put to practical use.

[0005] Moreover, there has been proposed a stencil sheet prepared by hot press-bonding a porous substrate comprising unstretched thermoplastic resin fibers to an unstretched thermoplastic resin film, followed by biaxial stretching to laminate them without using adhesives. It has been further proposed to use a porous substrate having a specific pore area ratio and a specific pore average diameter to improve sharpness of printed images and offset of ink. See, for example, JP-A-7-205564. However, in this case, uniformity of the solid portions is still insufficient depending on the distribution of fibers in a sectional direction of the substrate, and offset sometimes occurs. Moreover, after printing, when the printing paper is peeled off from the drum, the stencil sheet sometimes expands or contracts to cause unevenness in density.

[0006] The object of the present invention is to solve the above problems on conventional techniques, and to provide a stencil sheet which gives printed images excellent especially in uniformity of solid portions, is inhibited from causing uneven density and offset of ink, and, besides, is excellent in resolution of small letters, and furthermore to provide a method for perforating stencil sheets.

[0007] In order to attain the above object, the inventors have conducted an intensive research on the mechanism of the ink permeating through a stencil sheet. As a result, it has been found that permeability of ink through a stencil sheet should be considered, taking into consideration not only the state of the distribution of the fibers in planar direction of the substrate, but also the state of the distribution of the fibers in sectional direction, namely, the state of the three-dimensional distribution of the fibers of the substrate. Furthermore, it has been found that wet strength of the stencil sheet is important to obtain excellent printed images that are less in defects than in conventional techniques.

[0008] According to the present invention, the ink satisfactorily passes through the perforations of a perforated part of the stencil sheet when the perforated part meets an average airflow resistance of 0.05-0.15 Kpa · s/m, preferably 0.06-0.14 Kpa · s/m, more preferably 0.07-0.12 Kpa · s/m. If the average airflow resistance is lower than 0.05 Kpa · s/m, amount of the passing ink is too much, and there occur problems such as offset and blurring of the images at the time of printing. On the other hand, if the average airflow resistance is higher than 0.15 Kpa · s/m, portions through which the ink does not pass are made so as to form voids at the time of printing. Further, according to the present invention, when opening ratio of the perforated part is 20-50%, preferably 29-45%, the ink which passes through the perforations of the perforated part and is transferred to a printing paper forms minute picture elements, and the original is faithfully reproduced as a stencil printed image of uniform density, and especially, the solid portion is reproduced with little void. Herein, opening ratio is measured in terms of the film of a stencil sheet at a perforated part for black solid original of 100% in printing ratio. If the opening ratio is less than 20%, there are many unperforated portions, and thus there are

many voids in the printed image. On the other hand, if the opening ratio is more than 50%, ink readily passes through the sheet irrespective of the state of denseness, the state of distribution of fibers, and density and thickness of the substrate. As a result, offset

of ink occurs in the prints.

[0009] Thus, according to one aspect of the present invention, there is provided a stencil sheet comprising a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers, which has an average airflow resistance in a range of 0.05-0.15 Kpa · s/m as measured at a perforated part of 20-50 % in opening ratio.

[0010] According to another aspect of the present invention, there is provided a method for perforating a stencil sheet comprising a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers, in which perforation is made in said film to form many fine openings corresponding to an image to be printed, characterized in that said perforation is carried out to give an average airflow resistance of 0.05-0.15 Kpa · s/m at a perforated part of the stencil sheet.

[0011] According to still another aspect of the present invention, there is provided a method for perforating a stencil sheet comprising a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers, in which perforation is made in said film to form many fine openings corresponding to an image to be printed, characterized in that said perforation is carried out to give an opening ratio of 29-45% at a perforated part thereof.

[0012] The stencil sheet of the present invention comprises a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers.

[0013] As the thermoplastic resin film in the present invention, mention may be made of known films such as of polyester, polyamide, polypropylene, polyethylene, polyvinyl chloride, polyvinylidene chloride and copolymers thereof, and preferred is a polyester film from the point of perforation sensitivity.

[0014] As the thermoplastic fibers in the present invention, mention may be made of known fibers such as of polyester, polyamide, polyphenylene sulfide, polyacrylonitrile, polypropylene, polyethylene, and copolymers thereof, and preferred are polyester fibers from the point of heat stability at the time of perforation of the stencil sheet.

[0015] As the polyesters constituting the polyester film and the polyester fibers in the present invention, mention may be made of polyethylene terephthalate, polyethylene naphthalate, polybutylene terephthalate, copolymer of ethylene terephthalate and ethylene isophthalate, polyethylene-2,6-naphthalate, polyhexamethylene terephthalate, copolymer of hexamethylene terephthalate and 1,4-cyclohexanedimethylene terephthalate, etc.

[0016] The thermoplastic resin film in the present invention is preferably stretched, especially preferably biaxially stretched. Such stretched film can be produced, for example, by preparing an unstretched film by extruding a polymer on a casting drum using a known T-die extrusion method, and then stretching the unstretched film in lengthwise direction by a group of heating rolls, and, if necessary, stretching it in crosswise direction by feeding to a tenter and the like.

An unstretched film of the desired thickness can be produced by adjusting the slit width of head, the discharging amount of polymer, and the speed of revolution of the casting drum. Furthermore, the stretching can be performed at the desired stretch ratio by adjusting the revolution speed of the heating rolls or changing the width of the tenter.

[0017] In the present invention, thickness of the thermoplastic resin film is optionally determined depending on the required sensitivity and the like, but is usually 0.1-10  $\mu\text{m}$ , preferably 0.1-5  $\mu\text{m}$ , more preferably 0.1-3  $\mu\text{m}$ . If the thickness exceeds 10  $\mu\text{m}$ , perforation sensitivity is sometimes deteriorated, and if it is thinner than 0.1  $\mu\text{m}$ , film-forming stability is sometimes inferior.

[0018] The porous substrate in the present invention may be a paper, nonwoven fabric or woven fabric made from filaments comprising the above-mentioned thermoplastic fibers, or may be a screen gauze. The nonwoven fabric is preferred from the point of production cost.

[0019] Average fiber diameter of the porous substrate is preferably 2-10  $\mu\text{m}$ . If the average fiber diameter is less than 2  $\mu\text{m}$ , the stencil sheet is apt to crease to cause failure of perforation, resulting in unperforated portions. If it exceeds 10  $\mu\text{m}$ , passing of ink becomes uneven.

[0020] In the present invention, density of the porous substrate is preferably 0.1-0.2  $\text{g}/\text{m}^3$ , more preferably 0.12-0.17  $\text{g}/\text{m}^3$ . The density of the substrate can be optionally adjusted by the fiber diameter and the processing conditions such as stretching and heating. If the density is less than 0.1  $\text{g}/\text{m}^3$ , excess amount of the ink passes through the sheet to cause offset or blurring at the time of printing. If the density is more than 0.2  $\text{g}/\text{m}^3$ , there are portions through which the ink does not pass to cause formation of voids at the time of printing.

[0021] Basis weight of the porous substrate is preferably 1-30  $\text{g}/\text{m}^2$ , more preferably 2-20  $\text{g}/\text{m}^2$ , especially preferably 3-16  $\text{g}/\text{m}^2$ .

[0022] The nonwoven fabric used as the porous substrate in the present invention can be produced by direct melt spinning methods such as known melt blow method and spun bond method. According to the melt blow method, the nonwoven fabric is produced by discharging a molten polymer from a spinneret under blowing of a hot air against the polymer from the circumference of the spinneret, thereby making the discharged polymer into fine fibers, then blowing the fibers onto a rotating conveyor arranged at a given position to collect the fibers, and forming them into a web. The resulting web is stacked together with the web already formed to form a nonwoven fabric. The fibers are fused together by being fusion bonded to each other. The degree of fusion bonding of the fibers can be adjusted by suitably adjusting the collecting distance between the spinneret and the conveyor. Furthermore, the basis weight of the web and the diameter

of filaments can be optionally set by suitably adjusting the discharging amount of the polymer, the hot air temperature, the hot air flow rate, and the conveyor moving speed. The fibers spun by the melt blow method are made fine by the pressure of the hot air and solidified in the non-oriented or low-oriented state, so that thickness of the fibers is not uniform. Thus, the web is formed in the state of thick fibers and thin fibers being properly dispersed. Moreover, the polymer is solidified from the spinneret is rapidly cooled from the molten state to room or ambient temperature, and, therefore, is solidified in the state of low-crystallization close to an amorphous state.

**[0023]** The nonwoven fabric constituting the porous substrate of the present invention is preferably stretched and oriented, and birefringence ( $\Delta n$ ) of the individual fibers is preferably 0.1 or higher, more preferably 0.12 or higher, especially preferably 0.14 or higher. Crystallinity of the fibers is preferably 15% or higher, more preferably 20% or higher, especially preferably 25% or higher.

**[0024]** In the present invention, the thermoplastic resin film and the porous substrate may be laminated using adhesives under the condition of not lowering the perforation sensitivity of the film, but preferably they are laminated by heat fusion bonding without using adhesives from the point of sharpness of prints. Peeling strength between the film and the substrate is preferably 3 g/cm or more, more preferably 5 g/cm or more, especially preferably 10 g/cm or more.

**[0025]** The heat fusion bonding can be attained, for example, by obtaining an unstretched film by extrusion casting, and before subjecting it to the longitudinal stretching step, hot pressing it with an unstretched nonwoven fabric by use of heating rolls. Fusion bonding temperature is preferably between the glass transition temperature ( $T_g$ ) and the melting point ( $T_m$ ) of the thermoplastic resin film, and more preferably between the glass transition temperature ( $T_g$ ) and the cold crystallizing temperature ( $T_{cc}$ ). In the case of a polyester film, it is preferably in the range of  $T_g+10^\circ\text{C}$  -  $T_g+50^\circ\text{C}$ .

**[0026]** In the present invention, it is especially preferred to carry out co-stretching after the heat fusion bonding of the unstretched thermoplastic film and the nonwoven fabric. When co-stretching is carried out in the heat fusion bonded state, the film and the nonwoven fabric are integrated so as not to be separated, and thus suitable stretching can be performed. In this case, the fibers of the nonwoven fabric are fusion bonded at interlocking points or contact points to form a reticulation having contact points.

**[0027]** The polyester nonwoven fabric used for heat fusion bonding is most preferably unstretched, and if it is a stretched fabric, it is preferred that the stretching ratio is low and the degree of orientation is low. In this state, the birefringence ( $\Delta n$ ) of the fibers of the nonwoven fabric is preferably 0.03 or lower, more preferably 0.02 or lower, especially preferably 0.01 or lower. Crystallinity of the fibers is preferably 20% or lower, more preferably 15% or lower, especially preferably 10% or lower.

**[0028]** The method of co-stretching is not limited, and preferred is biaxial stretching and this may be either sequential biaxial stretching or simultaneous biaxial stretching. In the case of the sequential biaxial stretching, generally, first the stretching in lengthwise direction is carried out and then the stretching in crosswise direction is carried out, but the sequence of stretching may be reversed. The stretching temperature is preferably between the glass transition temperature ( $T_g$ ) and the cold crystallizing temperature ( $T_{cc}$ ) of the thermoplastic resin film. The stretching ratio is not limited, and is optionally determined depending on the kind of polymer constituting the thermoplastic resin film and the sensitivity required for the stencil sheet. Generally, it is preferably 2-8 times, more preferably 3-8 times in lengthwise and crosswise directions.

**[0029]** It is further preferred to subject the stencil sheet to a heat treatment after the co-stretching. Usually, the heat treatment is carried out at about  $80-260^\circ\text{C}$  for about 0.5-60 seconds.

**[0030]** In the present invention, two or more nonwoven fabrics which are the same or different in fiber diameter and basis weight and which are superposed may be stretched.

**[0031]** In the present invention, the stencil sheet can be perforated by any methods as far as numerous fine openings corresponding to an image to be printed can be formed through the thermoplastic resin film. Suitable are flash irradiation by halogen lamps, xenon lamps, flash bulb, etc., infrared irradiation, pulse irradiation by laser beams, etc., and thermal perforation by thermal heads, etc. In the case of using the stencil sheet of the present invention as a heat-sensitive stencil sheet, it is preferred that the melting point ( $T_{m1}$ ) of the thermoplastic resin film and the melting point ( $T_{m2}$ ) of the porous substrate satisfy the relation  $T_{m1} \leq T_{m2}$ .

**[0032]** In the present invention, in order to realize an opening ratio of the stencil sheet of 20-50%, when, for example, a thermal head is used for perforation, area and temperature applied to the film can be optionally adjusted by the size of elements of the thermal head and a pitch between the elements, and the energy introduced therein.

**[0033]** A release layer is preferably provided on the side of the thermoplastic resin film opposite to the side of the porous substrate for inhibition of adhesion to a perforation means such as thermal head. The release layer may be coated at any stage before or after stretching of the film, but preferably coated before the stretching in order to highly develop the effects of the present invention. Releasing agents such as silicone oil, silicone resin, fluorocarbon resin, etc. may be used as releasing agents. The releasing agent may contain various additives such as dispersing aid, surface active agent, preservative, and anti-foaming agent for the purpose of improving dispersibility of the releasing agent in a medium such as water. Thickness of the release

layer is preferably 0.005-0.4  $\mu\text{m}$ , more preferably 0.01-0.4  $\mu\text{m}$ . When the thickness of the release layer is 0.4  $\mu\text{m}$  or less, running property during perforation is satisfactory and the thermal head is hardly stained.

[0034] Furthermore, as far as the effects of the present invention are not damaged, the stencil sheet of the present invention may contain various additives such as antistatic agents, heat resisting agents, antioxidants, organic particles, inorganic particles, and pigments.

[0035] When stencil printing is performed using the stencil sheet of the present invention, the ink used is preferably a water-in-oil (W/O) emulsion ink. The W/O emulsion ink comprises, for example, about 10-70% by weight of an oil phase and about 90-30% by weight of a water phase. Furthermore, a colorant is contained in the oil phase or water phase, and amount of the colorant is preferably 1-30% by weight, more preferably 3-10% by weight of the total amount of the emulsion ink. Average particle size of the colorant is preferably in the range of 0.1-12  $\mu\text{m}$ . If the particle size is less than 0.1  $\mu\text{m}$ , even if the ink passes through the sheet, the colorant readily penetrates into the inside of the printing paper, and sufficient printing density cannot be obtained. If it is more than 12  $\mu\text{m}$ , the colorant is apt to cause clogging between fibers of the substrate, resulting in occurrence of voids (so-called white dots) on the prints.

[0036] The stencil sheet of the present invention has a wet tensile strength in at least one direction of preferably 200 gf/cm or more, more preferably 250 gf/cm or more, especially preferably 300 gf/cm or more. Hereupon, the wet tensile strength means a tensile strength when the surface of the porous substrate of the stencil sheet is impregnated with water, and in use, the direction satisfying the above wet tensile strength is preferably lengthwise direction, namely, the machine direction in feeding of the stencil sheet to the printing machine. If the strength is less than 200 gf/cm, strength at printing is not sufficient, and, hence, the sheet expands or contracts at the time of removal of the printing paper from the drum to cause uneven removal, and this sometimes leads to uneven density of printed images. On the other hand, if the strength is more than 300 gf/cm, the strength of the stencil sheet is assured to cause no expansion and contraction at the time of removal, and a stable printing performance can be obtained with no uneven density.

#### Examples

[0037] The present invention will be explained in more detail by the following examples. However, it should be construed that the present invention is not limited to the examples. First, methods for measurement and evaluation of the properties of the stencil sheet which are employed in the examples will be explained.

#### (1) Average airflow resistance:

[0038] The stencil sheet was subjected to perforation by a rotary stencil printing machine RISOGRAPH GR377 (trade mark) manufactured by Riso Kagaku Corporation using a black solid original of 100% in printing ratio, thereby to prepare a master. Then, the perforated part of the master was cut to a size of 10 cm  $\times$  10 cm, and air permeability was measured in a measurement area of 30 mm in diameter ( $\varnothing$ ) by an air permeation tester (KES-F8-API manufactured by Kato Teck Co. Ltd.). The measurement was conducted repeatedly 5 times, and the average value was employed as the average airflow resistance.

#### (2) Wet tensile strength of stencil sheet:

[0039] The stencil sheet was cut in lengthwise direction (i.e., machine direction in the printing machine) to obtain a sample of 1.5 cm in width and 10 cm in length. The sample was immersed in water to be well wetted, and, in this state, was pulled at a testing rate of 10 mm/min until it was broken, by a universal testing machine (SHIMADZU AUTOGRAPH AGS-D). The load when the sample elongated by 2% was divided by the width of the sample to obtain the strength.

#### (3) Measurement of opening ratio in perforated part:

[0040] The stencil sheet perforated in the above (1) was photographed by a light microscope, and the perforations made in the stencil sheet were read by a scanner (Scanjet 4C manufactured by Hewlett Packard Co., Ltd.), followed by conversion to binary signals (binarization). Then, perforation area was obtained and the opening ratio was calculated.

#### (4) Measurement of fiber diameter of the substrate:

[0041] Optional 10 portions of the nonwoven fabric of the stencil sheet were photographed by an electron microscope

(5) Measurement of basis weight of substrate:

[0042] The stencil sheet was cut to 210 × 297 mm, and weight thereof was measured and converted to a weight per  $m^2$ . The weight of the film was deducted from the resulting weight of the sheet to obtain the basis weight.

(6) Measurement of thickness of stencil sheet:

[0043] 10 stencil sheets were stacked and the thickness thereof was measured by PEACOCK (DIAL THICKNESS GAUGE manufactured by Ozaki Seisakusho Co., Ltd.). Then, thickness per one sheet was calculated.

(7) Evaluation of print:

[0044] Perforation and printing were carried out by a rotary stencil printing machine RISOGRAPH GR377 (trade mark) manufactured by Riso Kagaku Corporation. As originals, one which was completely solid state, namely 100% in printing ratio and one which was 25% in printing ratio with letters of 6-10.5 points and solid portions being present together were used. Uniformity in solid portions and unevenness in density were evaluated on the print obtained from the original of 100% in printing ratio, and resolution of small letters and offset were evaluated on the print obtained from the original of 25% in printing ratio.

#### Example 1

[0045] Polyethylene terephthalate ( $\eta=0.60$ ,  $T_m=254^\circ C$ ) was spun using a rectangular spinneret having 80 holes of 0.35 mm in diameter at a spinneret temperature of  $285^\circ C$  by melt blow method, and the fibers were dispersed and collected on a conveyor to prepare a nonwoven fabric having an average fiber diameter of 8.0  $\mu m$  and a basis weight of 110  $g/m^2$ .

[0046] Then, a copolymer polyester resin ( $\eta=0.65$ ,  $T_m=225^\circ C$ ) comprising 85 mol% of polyethylene terephthalate and 15 mol% of polyethylene isophthalate was extruded using an extruder of 40 mm in screw diameter at a T-die head temperature of  $275^\circ C$ , and cast on a cooling drum to prepare an unstretched film. The above nonwoven fabric was superposed on the unstretched film, and these were fed to heating rolls to perform heat fusion bonding of them at  $80^\circ C$  to obtain a laminate sheet.

[0047] The laminate sheet was stretched threefold between the heating rolls in machine direction, and then fed into a tenter type stretching machine to stretch the sheet threefold in crosswise direction, and, furthermore, heat treated at  $140^\circ C$  in the tenter to obtain a stencil sheet.

[0048] In the resulting stencil sheet, thickness of the film was 1.5  $\mu m$ , average fiber diameter of the substrate was 4.0  $\mu m$ , and basis weight of the substrate was 9.7  $g/m^2$ , and the stencil sheet had a thickness of 76  $\mu m$ . Moreover, in order to impart releasability from thermal head, a silicone oil was coated on the stencil sheet at a thickness of 0.01  $\mu m$  by a roll coater.

[0049] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1.

#### Example 2

[0050] A stencil sheet was prepared in the same manner as in Example 1, except that the nonwoven fabric used had an average fiber diameter of 9.5  $\mu m$  before stretching. In the resulting stencil sheet, thickness of the film was 1.5  $\mu m$ , average fiber diameter of the substrate was 4.75  $\mu m$ , and basis weight of the substrate was 9.7  $g/m^2$ , and the stencil sheet had a thickness of 75.0  $\mu m$ .

[0051] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1.

#### Example 3

[0052] A stencil sheet was prepared in the same manner as in Example 1, except that the nonwoven fabric used had an average fiber diameter of 10.5  $\mu m$  and a basis weight of 90  $g/m^2$  before stretching. In the resulting stencil sheet, thickness of the film was 1.6  $\mu m$ , average fiber diameter of the substrate was 5.2  $\mu m$ , and basis weight of the substrate

[0053] The results of the measurement and evaluation are shown in Table 1.

## Example 4

[0054] A stencil sheet was prepared in the same manner as in Example 1, except that the nonwoven fabric used had a basis weight of 90 g/m<sup>2</sup> before stretching. In the resulting stencil sheet, thickness of the film was 1.3 μm, average fiber diameter of the substrate was 5.0 μm, and basis weight of the substrate was 11.5 g/m<sup>2</sup>, and the stencil sheet had a thickness of 87.3 μm.

[0055] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1.

## Example 5

[0056] A stencil sheet was prepared in the same manner as in Example 1, except that the nonwoven fabric used had an average fiber diameter of 7.0 μm and a basis weight of 103 g/m<sup>2</sup> before stretching. In the resulting stencil sheet, thickness of the film was 1.6 μm, average fiber diameter of the substrate was 3.4 μm, and basis weight of the substrate was 8.6 g/m<sup>2</sup>, and the stencil sheet had a thickness of 60.0 μm.

[0057] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1.

## Example 6

[0058] A stencil sheet was prepared in the same manner as in Example 1, except that the nonwoven fabric used had a basis weight of 130 g/m<sup>2</sup> before stretching. In the resulting stencil sheet, thickness of the film was 1.6 μm, average fiber diameter of the substrate was 3.4 μm, and basis weight of the substrate was 12.0 g/m<sup>2</sup>, and the stencil sheet had a thickness of 89.6 μm.

[0059] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1.

## Example 7

[0060] A nonwoven fabric having an average fiber diameter of 6.6 μm and a basis weight of 90 g/m<sup>2</sup> and a nonwoven fabric having an average fiber diameter of 16 μm and a basis weight of 30 g/m<sup>2</sup> which were obtained by the same spinning method as in Example 1 were laminated with each other, and the laminate of nonwoven fabrics were laminated with the film of Example 1 in such a manner that the former nonwoven fabric contacted with the film, followed by co-stretching the laminate by the same method as in Example 1 to obtain a stencil sheet. In the resulting stencil sheet, thickness of the film was 1.5 μm, average fiber diameter of the first layer substrate was 3.3 μm, and basis weight of the first layer substrate was 8.2 g/m<sup>2</sup>, and average fiber diameter of the second layer substrate was 8.0 μm, and basis weight of the second layer substrate was 2.7 g/m<sup>2</sup>, and the stencil sheet had a thickness of 83 μm.

[0061] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1.

## Comparative Example 1

[0062] A film was previously prepared by stretching only the film in accordance with the stretching procedure of Example 1 until the film thickness reached 1.7 μm. This film was adhered with an adhesive to a substrate made from admixture of natural fibers and synthetic fibers having a basis weight of 10.5 g/m<sup>2</sup> and a thickness of 59.0 μm, thereby obtaining a stencil sheet.

[0063] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1. As shown in Table 1, voids (so-called white dots) were formed on the solid portions of the print, and printed image quality was inferior.

## Comparative Example 2

[0064] A stencil sheet having a thickness of 39.6 μm in which the thickness of the film was 1.3 μm, the average fiber diameter of the substrate was 5.0 μm, and the basis weight of the substrate was 9.0 g/m<sup>2</sup> was prepared by the method

[0065] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1. As shown in Table 1, the print had lateral-striped uneven density caused by uneven transfer of ink due to insufficient strength of the stencil sheet, and the transferring amount of ink was large because of too low passing resist-

ance of ink, resulting in non-uniformity and offset of ink.

#### Comparative Example 3

5 [0066] A stencil sheet having a thickness of 42.2  $\mu\text{m}$  in which the thickness of the film was 1.3  $\mu\text{m}$ , the average fiber diameter of the substrate was 6.1  $\mu\text{m}$ , and the basis weight of the substrate was 9.8  $\text{g/m}^2$  was prepared by the method of Example 1.

10 [0067] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1. As is clear from Table 1, the print had uneven density and offset of ink occurred as in Comparative Example 2.

#### Comparative Example 4

15 [0068] A stencil sheet having a thickness of 105  $\mu\text{m}$  in which the thickness of the film was 2.7  $\mu\text{m}$ , the average fiber diameter of the substrate was 4.3  $\mu\text{m}$ , and the basis weight of the substrate was 17.9  $\text{g/m}^2$  was prepared by the method of Example 1.

20 [0069] This stencil sheet was subjected to the above-mentioned measurement and evaluation. The results are shown in Table 1. As is clear from Table 1, because of too high passing resistance of ink, the print image had many voids and was low in resolution of small letters.

Table 1 (to be continued)

	Film thickness $\mu\text{m}$	Fiber diameter of substrate $\mu\text{m}$	Basis weight of substrate $\text{g}/\text{m}^2$	Thickness of stencil sheet $\mu\text{m}$	Density $\text{g}/\text{m}^3$	Average airflow resistance $\text{Kpa}\cdot\text{s}/\text{m}$	Wet strength $\text{gf}/\text{cm}$	Opening ratio $\%$
Comparative example 1	1.7	—	10.5	60.7	0.178	0.1713	380	22.5
Comparative example 2	1.3	5.0	9.0	39.6	0.235	0.0471	153	47.3
Comparative example 3	1.3	6.1	9.8	42.2	0.240	0.0412	183	28.3
Comparative example 4	2.7	4.3	17.9	105	0.175	0.2215	662	20.0
Example 1	1.5	4.0	9.7	76.0	0.130	0.0862	300	36.5
Example 2	1.5	4.75	9.7	75.0	0.132	0.0776	255	30.2
Example 3	1.6	5.2	8.1	65.0	0.128	0.0702	235	29.3
Example 4	1.3	5.0	11.5	87.3	0.134	0.0669	270	35.0
Example 5	1.6	3.4	8.6	60.0	0.147	0.1209	313	35.8
Example 6	1.6	3.4	12.0	89.6	0.136	0.1325	393	29.2
Example 7	1.5	3.3	8.2	83.0	—	0.1186	345	31.3
		8.0	2.7					

Table 1 (continued)

	Uniformity of solid portion	Uneven density due to separation from drum	Resolution of small letters	Offset
Comparative example 1	x	○	○	◎
Comparative example 2	○	x	△	x
Comparative example 3	△	x	△	x
Comparative example 4	x	○	x	◎
Example 1	◎	○	○	○
Example 2	◎	○	○	○
Example 3	◎	○	○	○
Example 4	○	○	○	○
Example 5	○	○	○	◎
Example 6	◎	○	○	◎
Example 7	◎	○	○	◎

Criteria of evaluation:

◎: Very good

○: Good

△: Practically acceptable

x: Practically unacceptable

[0070] As can be seen from Table 1, when opening ratio of the perforated stencil sheet is 20-50%, printed images free from voids and offset of ink and excellent in resolution of small letters can be obtained by specifying the average airflow resistance of the perforated part to be 0.05-0.15 Kpa · s/m. Furthermore, when the wet strength of the stencil sheet in longitudinal direction is 200 gf/cm or higher, uneven transfer of ink is inhibited, and uneven density is also diminished. Moreover, it can be seen that an opening ratio of the perforated part is preferably 29-45%.

[0071] According to the present invention, the ink passing properties through a perforated part of a stencil sheet is grasped by the conception of airflow resistance which includes the distribution state of the fibers of the substrate not

and show no offset of ink

## Claims

1. A stencil sheet comprising a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers, which has an average airflow resistance in a range of 0.05-0.15 Kpa • s/m as measured at a perforated part of 20-50 % in opening ratio.
2. A stencil sheet according to claim 1, which has a wet tensile strength of 200 gf/cm or more.
3. A stencil sheet according to claim 1, in which said thermoplastic resin film is a polyester resin film.
4. A stencil sheet according to claim 1, in which said thermoplastic fibers are made of a polyester resin.
5. A method for perforating a stencil sheet comprising a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers, in which perforation is made in said film to form many fine openings corresponding to an image to be printed, characterized in that said perforation is carried out to give an average airflow resistance of 0.05-0.15 Kpa • s/m at a perforated part of the stencil sheet.
6. A method according to claim 5, in which said film has an opening ratio of 20-50% at said perforated part of the stencil sheet.
7. A method for perforating a stencil sheet comprising a laminate of a thermoplastic resin film and a porous substrate mainly composed of thermoplastic fibers, in which perforation is made in said film to form many fine openings corresponding to an image to be printed, said perforation being carried out so that said film has an opening ratio of 29-45% at said perforated part of the stencil sheet.



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 99 11 7651

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THE HAGUE		23 November 1999	Martins Lopes, L

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 11 7651

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
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